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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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7590	04/19/2005		EXAMINER	
James W. Huffman 1832 N. Cascade Ave Colorado Springs, CO 80907			HUISMAN, DAVID J	
			ART UNIT	PAPER NUMBER
			2183	

DATE MAILED: 04/19/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

<b>Office Action Summary</b>	Application No.	Applicant(s)	
	09/849,822	HENRY ET AL.	
	Examiner David J. Huisman	Art Unit 2183	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

#### Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

#### Status

- 1) Responsive to communication(s) filed on 01 February 2005.
- 2a) This action is FINAL.                    2b) This action is non-final.
- 3) Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

#### Disposition of Claims

- 4) Claim(s) 1-13 and 19-39 is/are pending in the application.
- 4a) Of the above claim(s) \_\_\_\_\_ is/are withdrawn from consideration.
- 5) Claim(s) \_\_\_\_\_ is/are allowed.
- 6) Claim(s) 1-13 and 19-39 is/are rejected.
- 7) Claim(s) \_\_\_\_\_ is/are objected to.
- 8) Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

#### Application Papers

- 9) The specification is objected to by the Examiner.
- 10) The drawing(s) filed on 04 May 2001 is/are: a) accepted or b) objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

#### Priority under 35 U.S.C. § 119

- 12) Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) All    b) Some \* c) None of:
  1. Certified copies of the priority documents have been received.
  2. Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
  3. Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

\* See the attached detailed Office action for a list of the certified copies not received.

#### Attachment(s)

- 1) Notice of References Cited (PTO-892)
- 2) Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 3) Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)  
Paper No(s)/Mail Date 01 February 2005.
- 4) Interview Summary (PTO-413)  
Paper No(s)/Mail Date. \_\_\_\_\_.
- 5) Notice of Informal Patent Application (PTO-152)
- 6) Other: \_\_\_\_\_.

**DETAILED ACTION**

1. Claims 1-13 and 19-39 have been examined.

*Papers Submitted*

2. It is hereby acknowledged that the following papers have been received and placed of record in the file: RCE and Amendment as received on 2/1/2005.

*Specification*

3. The title of the invention is not descriptive. A new title is required that is clearly indicative of the invention to which the claims are directed. The examiner recommends incorporating the idea of multiple stacks and their functionality.

*Withdrawn Rejections*

4. Applicant, via amendment, has overcome both the prior-art and non-prior-art rejections set forth in the previous Office Action. Consequently, these rejections are hereby withdrawn by the examiner and all arguments associated with these rejections are moot. However, upon further consideration, a new ground(s) of rejection is applied below.

*Claim Rejections - 35 USC § 102*

5. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

6. Claim 1 is rejected under 35 U.S.C. 102(b) as being anticipated by Hoyt et al., U.S.

Patent No. 5,604,877 (herein referred to as Hoyt).

7. Referring to claim 1, Hoyt has taught an apparatus in a processor for speculatively performing a return instruction, comprising:

a) first and second call/return stacks, for providing first and second return addresses, respectively. See Fig.2, steps 1 and 2, column 10, lines 62-67, and column 13, lines 49-63. Note that upon fetching what is believed to be a return instruction, a first return address is popped from a first stack using the BTB-TOS pointer. After decoding and verifying that a return instruction has been encountered, a second return address is popped from a second stack using the BAC-TOS pointer. It should be realized from Fig.6 that the first stack is the memory region comprising locations ranging from the base of the stack to the BTB-TOS pointer while the second stack is the memory region comprising locations ranging from the base of the stack to the BAC-TOS pointer. Although the stacks share some memory locations, the stacks are different as they are defined by different top of stack (TOS) pointers. In addition, sometimes, the first return address may be retrieved from a return register (Fig.5, component 45). See column 10, lines 54-61. This register is a one-entry register stack which has return addresses pushed onto it (when calls occur - column 10, lines 4-7) and popped off of it (when returns occur - column 10, lines 54-61).

b) a comparator, coupled to said first and second call/return stacks, for comparing said first and second return addresses prior to the return instruction reaching an execution stage of a pipeline of the processor, wherein said execution stage is configured to finally resolve the return

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instruction. See Fig.2 and column 13, lines 49-63. The comparison occurs before the execution stage which is when the return is finally resolved (step 3).

c) control logic, coupled to said comparator, for controlling the processor to branch to said first return address, said control logic subsequently controlling the processor to branch to said second return address if said comparator indicates said first and second return addresses do not match.

See Fig.2, steps 1 and 2, column 4, lines 15-25, and column 13, lines 49-63.

8. Referring to claim 2, Hoyt has taught an apparatus as described in claim 1. Hoyt has further taught that said second call/return stack is configured to provide said second return address in response to instruction decode logic decoding a return instruction. See column 10, lines 49-63, and note that the providing of the second address is part of the stage 2-functionality (decoding). See column 12, lines 53-54.

9. Referring to claim 3, Hoyt has taught an apparatus as described in claim 1. Hoyt has further taught that said first call/return stack speculatively provides said first return address before decoding of said return instruction. See Fig.2, step 1.

10. Referring to claim 4, Hoyt has taught an apparatus as described in claim 3. Hoyt has further taught that said first call/return stack speculatively provides said first return address in response to a fetch address, said fetch address selecting a cache line of an instruction cache. See column 8, lines 12-19, and lines 42-46.

11. Referring to claim 5, Hoyt has taught an apparatus as described in claim 4. Hoyt has further taught that said first call/return stack speculatively provides said first return address in response to said fetch address whether or not said return instruction is present in said cache line. See column 4, lines 15-19, and column 13, lines 7-10.

12. Referring to claim 6, Hoyt has taught an apparatus as described in claim 1. Hoyt has further taught a branch target address cache (BTAC), coupled to said first call/return stack, for caching a plurality of indications of whether a corresponding plurality of instructions previously executed by the processor are return instructions. See Fig.5, component 40, and column 8, lines 59-62.

13. Referring to claim 7, Hoyt has taught an apparatus as described in claim 6. Hoyt has further taught that said first call/return stack provides said first return address in response to said BTAC providing one of said plurality of indications, wherein said one of said plurality of indications indicates that said corresponding instruction is a return instruction. See column 9, Table 2, and note the action taken for a return-type instruction.

14. Referring to claim 8, Hoyt has taught an apparatus as described in claim 7. Hoyt has further taught that said BTAC provides said one of said plurality of indications in response to an instruction cache fetch address. See column 8, lines 41-45, and Fig.5. Note that an instruction pointer (IP), which is applied to cache to fetch instructions, is also sent to the BTAC.

15. Referring to claim 19, Hoyt has taught a microprocessor for predicting return instruction target addresses, comprising:

- a) an instruction cache, for generating a line of instruction bytes selected by a fetch address, said fetch address received from an address bus. See Fig.3, component 35, and column 5, lines 11-19.
- b) address selection logic, coupled to said address bus, for selecting said fetch address and providing said fetch address on said address bus. See Fig.3 and note that the buses emanating from fetch unit (address selection logic) 30 are address buses.

- c) a branch target address cache (BTAC), coupled to said address bus, for caching indications of previously executed return instructions and for providing one of said indications in response to said fetch address. See Fig.5, component 40, and column 8, lines 59-62.
- d) a first call/return stack, coupled to said BTAC, for providing a first return address to said address selection logic in response to said one of said indications. See Fig.5, components 45 and 51, and column 10, lines 55-67. Note that a first address is provided either from the return register (if valid) or a stack. The return register is a one-entry register stack which has return addresses pushed onto it (when calls occur - column 10, lines 4-7) and popped off of it (when returns occur - column 10, lines 54-61).
- e) decode logic, coupled to said instruction cache, for decoding said line of instruction bytes. See Fig.5, component 60.
- f) a second call/return stack, coupled to said decode logic, for providing a second return address to said address selection logic in response to said decode logic indicating that a return instruction is present in said line of instruction bytes. See column 13, lines 7-10, and lines 49-63. Note that an address is provided from a second stack (with respect to the register being a first stack). On the other hand, it should be realized from Fig.5 and Fig.6 that the first stack is the memory region comprising locations ranging from the base of the stack to the BTB-TOS pointer while the second stack is the memory region comprising locations ranging from the base of the stack to the BAC-TOS pointer. Although the stacks share some memory locations, the stacks are different as they are defined by different top of stack (TOS) pointers.
- g) an execution stage, coupled to decode logic, for finally resolving return instructions, wherein said first and second call/return stacks provide said first and second return addresses to said

address selection logic prior to said return instruction reaching said execution stage. See Fig.2, step 3 and note that returns are resolved in the execution stage while the first and second stack addresses are provided in steps 1 and 2, respectively.

16. Referring to claim 20, Hoyt has taught a microprocessor as described in claim 19. Hoyt has further taught that said first call/return stack provides said first return address before said decode logic decodes said line of instruction bytes. See Fig.2, step 1.

17. Referring to claim 21, Hoyt has taught a microprocessor as described in claim 19. Hoyt has further taught that said branch target address cache provides said one of said indications in response to said fetch address whether or not a return instruction is present in said line of instruction bytes. See column 8, lines 59-62.

18. Referring to claim 22, Hoyt has taught a microprocessor as described in claim 19. Hoyt has further taught that said first call/return stack provides said first return address in response to said one of said indications indicating said one of said previously executed return instructions is potentially present in said line of instruction bytes. See column 8, lines 12-19, and lines 59-62.

19. Referring to claim 23, Hoyt has taught a microprocessor as described in claim 19. Hoyt has further taught control logic, coupled to said BTAC, configured to control said address selection logic to select said first return address during a first period. See Fig.2, step 1, and the selector components in BTAC 40 (Fig.5).

20. Referring to claim 24, Hoyt has taught a microprocessor as described in claim 23. Hoyt has further taught a comparator, coupled to said first and second call/return stacks, for comparing said first and second return addresses. See column 13, lines 49-63.

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21. Referring to claim 25, Hoyt has taught a microprocessor as described in claim 24. Hoyt has further taught that said control logic is further configured to control said address selection logic to select said second return address subsequent to controlling said address selection logic to select said first return address if said comparator indicates said first and second return addresses do not match. See column 13, lines 49-63.

22. Referring to claim 26, Hoyt has taught a microprocessor as described in claim 19. Hoyt has further taught that said second call/return stack provides said second return address subsequent to said first call/return stack providing said first return address. See column 13, lines 49-63.

23. Referring to claim 27, Hoyt has taught a method for speculatively branching a microprocessor to a target address of a return instruction, the microprocessor including an execution stage for finally resolving the return instruction, the method comprising:

- a) generating a first target address by a first call/return stack. See Fig.2, step 1, and column 9, Table 2 (note the action taken for a return instruction...a stack provides an address).
- b) branching to said first target address. See column 4, lines 15-25.
- c) generating a second target address by a second call/return stack subsequent to said branching to said first target address. See column 13, lines 49-63.
- d) comparing said first and second target addresses prior to the return instruction reaching the execution stage. See column 13, lines 49-63, and note that this step corresponds to step 2 in Fig.2 (before execution)
- e) branching to said second target address if said first and second target addresses do not match. See column 13, lines 49-63.

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24. Referring to claim 28, Hoyt has taught a method as described in claim 27. Hoyt has further taught that said branching to said first target address comprises selecting said first target address and providing said first target address as a fetch address to an instruction cache in the microprocessor. See column 8, lines 12-19 and 41-48, and notice that a first address is provided as a prediction. The instruction pointer is sent to fetch instructions from memory 35 (Fig.3), which comprises cache (column 5, lines 11-19).

25. Referring to claim 29, Hoyt has taught a method as described in claim 28. Hoyt has further taught that said generating said first target address comprises said first call/return stack generating said first target address in response to a previous fetch address that was provided to said instruction cache. See column 8, lines 12-19, and lines 41-48.

26. Referring to claim 30, Hoyt has taught a method as described in claim 29. Hoyt has further taught that said generating said first target address is performed whether or not a return instruction is present in an instruction cache line selected by said fetch address. See column 4, lines 15-19, and column 13, lines 7-10.

27. Referring to claim 31, Hoyt has taught a method as described in claim 29. Hoyt has further taught decoding a return instruction present in a line of instruction bytes selected from said instruction cache by said fetch address, wherein said decoding said return instruction present in said line of instruction bytes is performed subsequent to said branching to said first target address. Note from Fig.2 that the branching to the first target occurs in step 1, whereas decoding occurs in step 2.

28. Referring to claim 32, Hoyt has taught a method as described in claim 31. Hoyt has further taught that said generating said second target address comprises said second call/return

stack generating said second target address in response to said decoding said return instruction present in said line of instruction bytes. Column 12, lines 53-54, begins the decoding section (what happens during decoding). In column 13, lines 49-63, the second stack provides the address in response to decoding.

29. Referring to claim 33, Hoyt has taught a method as described in claim 27. Hoyt has further taught that said generating said first target address comprises popping said first target address off said first call/return stack. See column 10, lines 62-67, and Fig.6.

30. Referring to claim 34, Hoyt has taught a method as described in claim 33. Hoyt has further taught pushing said first target address onto said first call/return stack prior to said popping said first target address off said first call/return stack. See the abstract and Fig.6, and note that a call will push a return address onto the stack prior to it being popped off..

31. Referring to claim 35, Hoyt has taught a method as described in claim 34. Hoyt has further taught calculating said first target address prior to said pushing. See Fig.6, and note the last step under the “call instruction encountered” heading. The address after the call instruction (which is determined) is pushed onto the stack.

32. Referring to claim 38, Hoyt has taught a method as described in claim 34. Hoyt has further taught that said pushing is performed in response to an instruction cache fetch address. Clearly, in response to a fetch address, if a call is detected, a push will be performed.

33. Referring to claim 39, Hoyt has taught a microprocessor for predicting return instruction target addresses.

a) an instruction cache, for providing a line of instructions in response to a fetch address received on an address bus. See Fig.3, component 35, and column 5, lines 11-19.

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- b) a multiplexer, having a plurality of inputs, configured to select one of said plurality of inputs for provision on said address bus as said fetch address to said instruction cache. See Fig.5 and note the multiplexers in circuit 40 which select fetch addresses to send to fetch logic.
- c) a speculative branch target address cache (BTAC), coupled to said address bus, for indicating a speculative presence of a return instruction in said line of instructions. See column 8, lines 59-62.
- d) a speculative call/return stack, coupled to said speculative BTAC, for providing a speculative return address to a first of said plurality of multiplexer inputs in response to said speculative BTAC indicating said speculative presence of said return instruction. See column 9, Table 2 (note the action for return instructions) and see Fig.5, components 45 and 51, and column 10, lines 55-67. Note that a first address is provided either from the return register (if valid) or a stack. The return register is a one-entry register stack which has return addresses pushed onto it (when calls occur - column 10, lines 4-7) and popped off of it (when returns occur - column 10, lines 54-61).
- e) decode logic, configured to receive and decode said line of instructions. See Fig.5, component 60.
- f) a non-speculative call/return stack, coupled to said decode logic, for providing a non-speculative return address to a second of said plurality of multiplexer inputs in response to said decode logic indicating that said return instruction is actually present in said line of instructions. See column 13, lines 7-10, and lines 49-63. Note that an address is provided from a second stack (with respect to the register being a first stack). On the other hand, it should be realized from Fig.5 and Fig.6 that the first stack is the memory region comprising locations ranging from the

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base of the stack to the BTB-TOS pointer while the second stack is the memory region comprising locations ranging from the base of the stack to the BAC-TOS pointer. Although the stacks share some memory locations, the stacks are different as they are defined by different top of stack (TOS) pointers.

g) a comparator, coupled to said speculative and non-speculative call/return stacks, for comparing said speculative and non-speculative return addresses prior to said return instruction reaching an execution stage of a pipeline of the processor, wherein said execution stage is configured to finally resolve the return instruction. See Fig.2 and column 13, lines 49-63. The comparison occurs before the execution stage which is when the return is finally resolved (step 3).

h) wherein said multiplexer selects said speculative return address in a first instance, and selects said non-speculative return address in a second instance subsequent to said first instance if said comparator indicates that said speculative and non-speculative return addresses do not match.

See Fig.2, steps 1 and 2, column 4, lines 15-25, and column 13, lines 49-63.

#### *Claim Rejections - 35 USC § 103*

34. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

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35. Claims 1-7, 27, 33-35, and 38 are rejected under 35 U.S.C. 103(a) as being unpatentable over Gochman et al., U.S. Patent No. 5,964,868 (as applied in the previous Office Action and herein referred to as Gochman) in view of Hoyt, as applied above.

36. Referring to claim 1, Gochman has taught an apparatus in a processor for speculatively performing a return instruction, comprising:

- a) first and second call/return stacks, for providing first and second return addresses, respectively. See Fig.1, and column 3, lines 33-53. Note that a speculative (predicted) return address is produced by the speculative stack and an actual return address is produced by the actual return stack.
- b) a comparator, coupled to said first and second call/return stacks, for comparing said first and second return addresses. See column 7, lines 20-25, and Fig.3, and note that a determination is made (via comparison) as to whether a branch has been mispredicted or not.
- c) control logic, coupled to said comparator, for controlling the processor to branch to said first return address, said control logic subsequently controlling the processor to branch to said second return address if said comparator indicates said first and second return addresses do not match. As the Fig.3 shows, if a misprediction did not occur (the speculative return address was correct, i.e., it matches the actual return address), then the process is done and execution continues. However, if a misprediction did occur (the speculative return address was incorrect, i.e., it does not match the actual address), then the instruction fetch must be restarted at the actual return address. See column 7, lines 20-32, for further details.
- d) Gochman has not taught that comparing an address from a second stack with a first address occurs prior to the return instruction reaching an execution stage of a pipeline of the processor,

wherein said execution stage is configured to finally resolve the return instruction. However, Hoyt has taught such a concept. See Fig 2, steps 1, 2, and 3. Both Gochman and Hoyt teach predicting a return address as early as possible and verifying a prediction after executing the return instruction. Hoyt teaches the concept which Gochman lacks, and that is verifying the prediction before the execution stage. See Fig.2, step 2, and column 13, lines 49-63. The idea behind Hoyt is to speculatively predict returns as soon as possible (Fig.2, step 1), even as the existence of the return is unknown. Then before, the instruction is executed, it is decoded, verified by the decoding process to be a return instruction, and if so, makes sure the prediction is proper (Fig.2, step 2, and column 13, lines 7-10). When comparing Gochman and Hoyt, one of ordinary skill in the art would've realized that in Gochman, a prediction is made early and the verification happens during execution, which means a misprediction is detected further from the initial prediction. With Hoyt, verification happens before execution and therefore, a misprediction is noticed sooner, thereby allowing Hoyt to correct the problem in less time. As a result, in order to verify predictions sooner in Gochman, which would allow for earlier correction of mispredictions, it would have been obvious to one of ordinary skill in the art at the time of the invention to modify Gochman to include the comparing prior to execution feature set forth in Hoyt.

37. Referring to claim 2, Gochman in view of Hoyt has taught an apparatus as described in claim 1. Hoyt has further taught that said second call/return stack is configured to provide said second return address in response to instruction decode logic decoding a return instruction. See Fig 2, step 2, and column 13, lines 49-63.

38. Referring to claim 3, Gochman in view of Hoyt has taught an apparatus as described in claim 1. Gochman has further taught that said first call/return stack speculatively provides said first return address before decoding of said return instruction. See Fig. 2 and note that the first (speculative) return address is popped from the first (speculative) stack in the PF stage, which occurs before the D1 and D2 decode stages.

39. Referring to claim 4, Gochman in view of Hoyt has taught an apparatus as described in claim 3. Gochman has further taught that said first call/return stack speculatively provides said first return address in response to a fetch address, said fetch address selecting a cache line of an instruction cache. See column 6, lines 4-32, and lines 48-56. Note that a fetch address is applied to the branch target buffer cache, which is an instruction cache because it caches information regarding branch instructions.

40. Referring to claim 5, Gochman in view of Hoyt has taught an apparatus as described in claim 4. Gochman has further taught that said first call/return stack speculatively provides said first return address in response to said fetch address whether or not said return instruction is present in said cache line. See Fig. 4 and note that a return address (from stacks 51) is sent to a single multiplexer within branch prediction circuit 40. Therefore, the address is provided regardless of whether or not a return instruction exists. However, the multiplexer will not select the return address prediction if a return instruction does not exist within the cache. For instance, if the cache line includes an ordinary branch instruction (call), but not a return, then the multiplexer will select the address supplied by cache 41 as opposed to the address supplied by stack 51.

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41. Referring to claim 6, Gochman in view of Hoyt has taught an apparatus as described in claim 1. Gochman has further taught a branch target address cache (BTAC), coupled to said first call/return stack, for caching a plurality of indications of whether a corresponding plurality of instructions previously executed by the processor are return instructions. See Fig.4, component 41, and column 6, lines 4-25, and note that the type of branch, which includes the return-type, is cached.

42. Referring to claim 7, Gochman in view of Hoyt has taught an apparatus as described in claim 6. Gochman has further taught that said first call/return stack provides said first return address in response to said BTAC providing one of said plurality of indications, wherein said one of said plurality of indications indicates that said corresponding instruction is a return instruction. See column 6, lines 4-56. It should be noted that when a "hit" occurs in the cache, the system has fetched a branch instruction. The cache determines what type of branch it is (call, return, etc.) and based on the type, the appropriate action is performed. In the case of a return instruction, the speculative stack is popped.

43. Referring to claim 27, Gochman has taught a method for speculatively branching a microprocessor to a target address of a return instruction, the microprocessor including an execution stage for finally resolving the return instruction, comprising:

- a) generating a first target address by a first call/return stack. See Fig.1, component 51 (speculative return stack), and note that it generates a return target address in the PF stage shown in Fig.2
- b) branching to said first target address. See column 4, lines 35-45.

c) generating a second target address by a second call/return stack subsequent to said branching to said first target address. See Fig.1, component 55 (actual return stack), and note that it generates a return target address in the E stage shown in Fig.2.

d) comparing said first and second target addresses. See column 7, lines 20-22.

e) and branching to said second target address if said first and second target addresses do not match. See column 7, lines 26-30, and Fig.3 (the “Branch Mispredicted?” step). Note that when the addresses are compared, if they are different, then the return was mispredicted. This causes the fetch unit to restart fetching at the second (actual) target address.

f) Gochman has not taught that comparing an address from a second stack with a first address occurs prior to the return instruction reaching the execution stage. However, Hoyt has taught such a concept. See Fig.2, steps 1, 2, and 3. Both Gochman and Hoyt teach predicting a return address as early as possible and verifying a prediction after executing the return instruction. Hoyt teaches the concept which Gochman lacks, and that is verifying the prediction before the execution stage. See Fig.2, step 2, and column 13, lines 49-63. The idea behind Hoyt is to speculatively predict returns as soon as possible (Fig.2, step 1), even as the existence of the return is unknown. Then before, the instruction is executed, it is decoded, verified by the decoding process to be a return instruction, and if so, makes sure the prediction is proper (Fig.2, step 2, and column 13, lines 7-10). When comparing Gochman and Hoyt, one of ordinary skill in the art would've realized that in Gochman, a prediction is made early and the verification happens during execution, which means a misprediction is detected further from the initial prediction. With Hoyt, verification happens before execution and therefore, a misprediction is noticed sooner, thereby allowing Hoyt to correct the problem in less time. As a result, in order to

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verify predictions sooner in Gochman, which would allow for earlier correction of mispredictions, it would have been obvious to one of ordinary skill in the art at the time of the invention to modify Gochman to include the comparing prior to execution feature set forth in Hoyt.

44. Referring to claim 33; Gochman in view of Hoyt has taught a method as described in claim 27. Gochman has further taught that said generating said first target address comprises popping said first target address off said first call/return stack. See column 6, lines 48-56. Note that after the return address is obtained, the top-of-stack pointer (TOS pointer 53) is incremented, effectively popping the stack.

45. Referring to claim 34, Gochman in view of Hoyt has taught a method as described in claim 33. Gochman has further taught pushing said first target address onto said first call/return stack prior to said popping said first target address off said first call/return stack. See column 2, lines 29-37.

46. Referring to claim 35, Gochman in view of Hoyt has taught a method as described in claim 34. Gochman has further taught calculating said first target address prior to said pushing. See column 4, lines 30-33, and note that the address that is pushed onto the stack is the address of the instruction following the call instruction. Therefore, that address is calculated with respect to the call instruction and then pushed onto the stack. See column 6, lines 44-47, as well, for the calculation means.

47. Referring to claim 38, Gochman in view of Hoyt has taught a method as described in claim 34. Gochman has further taught that said pushing is performed in response to an

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instruction cache fetch address. See column 6, lines 4-47, and note that in response to a fetch address, if a call is detected, a push will be performed.

***Claim Rejections - 35 USC § 103***

48. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

49. Claims 8, 19-26, 28-32, and 39 are rejected under 35 U.S.C. 103(a) as being unpatentable over Gochman in view of Hoyt, as applied above.

50. Referring to claim 8, Gochman in view of Hoyt has taught an apparatus as described in claim 7. Gochman in view of Hoyt has not explicitly taught that said BTAC provides said one of said plurality of indications in response to an instruction cache fetch address. However, Official Notice is taken that instruction caches from which instructions are fetched are well known and accepted in the art. Instructions are always fetched from some form of memory, whether it be an instruction cache, main memory, etc. However, an instruction cache is much faster than main memory, and therefore, to increase fetching speed, and ultimately execution speed, it would have been obvious to one of ordinary skill in the art at the time of the invention to have Gochman's instruction fetch unit (Fig.4, component 30) coupled to an instruction cache.

51. Referring to claim 19, Gochman has taught a microprocessor for predicting return instruction target addresses.

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- a) Gochman has not taught an instruction cache, for generating a line of instruction bytes selected by a fetch address, said fetch address received from an address bus. However, Official Notice is taken that instruction caches from which instruction bytes are fetched are well known and accepted in the art. Instructions are always fetched from some form of memory, whether it be an instruction cache, main memory, etc. However, an instruction cache is much faster than main memory, and therefore, to increase fetching speed, and ultimately execution speed, it would have been obvious to one of ordinary skill in the art at the time of the invention to have Gochman's instruction fetch unit (Fig.4, component 30) coupled to an instruction cache. Also, addresses are inherently placed on an address bus.
- b) address selection logic, coupled to said address bus, for selecting said fetch address and providing said fetch address on said address bus. See Fig.4, and note the multiplexer which selects an address from either the stack(s), the branch target cache, or the write-results stage of the pipeline. This logic will determine the next fetch address which will be applied on the address bus by fetch logic 30.
- c) a branch target address cache (BTAC), coupled to said address bus, for caching indications of previously executed return instructions and for providing one of said indications in response to said fetch address. See Fig.4, component 41, and column 6, lines 4-56, and note that the type of branch (indication), which includes the return-type, is cached. It should be noted that when a "hit" occurs in the cache (in response to an applied fetch address), the system has fetched a branch instruction. The cache determines what type of branch it is (call, return, etc.) and based on the type, the appropriate action is performed. In the case of a return instruction, the speculative stack is popped.

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- d) a first call/return stack, coupled to said BTAC, for providing a first return address to said address selection logic in response to said one of said indications. See column 6, lines 4-56, and Figs.1 and 4, component 51.
- e) decode logic, coupled to said instruction cache, for decoding said line of instruction bytes. See Fig.4, component 60.
- f) a second call/return stack, coupled to said decode logic, for providing a second return address to said address selection logic in response to said decode logic indicating that a return instruction is present in said line of instruction bytes. See Figs.1 and 4, component 55. Note that this stack provides an actual address, via popping, during the E (execute) stage (Fig.2).
- g) Gochman has taught an execution stage, coupled to decode logic, for finally resolving return instructions. Gochman has not taught that the second stack provides said second address to said address selection logic prior to said return instruction reaching said execution stage. However, Hoyt has taught such a concept. See Fig.2, steps 1, 2, and 3. Both Gochman and Hoyt teach predicting a return address as early as possible and verifying a prediction after executing the return instruction. Hoyt teaches the concept which Gochman lacks, and that is verifying the prediction before the execution stage. See Fig.2, step 2, and column 13, lines 49-63. The idea behind Hoyt is to speculatively predict returns as soon as possible (Fig.2, step 1), even as the existence of the return is unknown. Then before, the instruction is executed, it is decoded, verified by the decoding process to be a return instruction, and if so, makes sure the prediction is proper (Fig.2, step 2, and column 13, lines 7-10). When comparing Gochman and Hoyt, one of ordinary skill in the art would've realized that in Gochman, a prediction is made early and the verification happens during execution, which means a misprediction is detected further from the

initial prediction. With Hoyt, verification happens before execution and therefore, a misprediction is noticed sooner, thereby allowing Hoyt to correct the problem in less time. As a result, in order to verify predictions sooner in Gochman, which would allow for earlier correction of mispredictions, it would have been obvious to one of ordinary skill in the art at the time of the invention to modify Gochman to have a second stack provide the second address prior to execution as set forth in Hoyt.

52. Referring to claim 20, Gochman in view of Hoyt has taught a microprocessor as described in claim 19. Gochman has further taught that said first call/return stack provides said first return address before said decode logic decodes said line of instruction bytes. See Fig.2 and note that the first (speculative) return address is popped from the first (speculative) stack in the PF stage, which occurs before the D1 and D2 decode stages.

53. Referring to claim 21, Gochman in view of Hoyt has taught a microprocessor as described in claim 19. Gochman has further taught that said branch target address cache provides said one of said indications in response to said fetch address whether or not a return instruction is present in said line of instruction bytes. For instance, if a call instruction is encountered, then the branch target address cache will provide an indication indicating that the encountered instruction is a call instruction. More specifically, the cache line does not have to include a return instruction for an indication to be provided by the branch cache.

54. Referring to claim 22, Gochman in view of Hoyt has taught a microprocessor as described in claim 19. Gochman has further taught that said first call/return stack provides said first return address in response to said one of said indications indicating said one of said previously executed return instructions is potentially present in said line of instruction bytes. See

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column 6, lines 4-56. It should be noted that when a "hit" occurs in the cache, the system has fetched a branch instruction. The cache determines what type of branch it is (call, return, etc.) and based on the type, the appropriate action is performed. In the case of a return instruction, the speculative stack is popped. Note that a return instruction is potentially present in the cache line because the cache line has the capability of holding a return instruction.

55. Referring to claim 23, Gochman in view of Hoyt has taught a microprocessor as described in claim 19. Gochman has further taught control logic, coupled to said BTAC, configured to control said address selection logic to select said first return address during a first period. Note that the first address is supplied during the PF stage shown in Fig.2. It is inherent that some control logic exists which makes this address available at this particular stage.

56. Referring to claim 24, Gochman in view of Hoyt has taught a microprocessor as described in claim 23. Gochman has further taught a comparator, coupled to said first and second call/return stacks, for comparing said first and second return addresses. Although a comparator is not explicitly shown in Gochman's figures, this component inherently exists because Fig.3 shows a step in which a determination is made as to whether a branch has been mispredicted or not. In order to determine if a misprediction has been made, the speculative and actual return addresses must be compared.

57. Referring to claim 25, Gochman in view of Hoyt has taught a microprocessor as described in claim 24. Gochman has further taught that said control logic is further configured to control said address selection logic to select said second return address subsequent to controlling said address selection logic to select said first return address if said comparator indicates said first and second return addresses do not match. Note that if the second address does not match

the first, a misprediction has occurred, and the system must be fetching at the second (actual) address which is provided during the execution (E) stage, which is after the stage in which the first (speculative) address was selected. See Fig.2.

58. Referring to claim 26, Gochman in view of Hoyt has taught a microprocessor as described in claim 19. Gochman has further taught that said second call/return stack provides said second return address subsequent to said first call/return stack providing said first return address. See Fig.2 and note that the speculative return address is supplied in the PF stage and the actual return address is supplied during the E stage.

59. Referring to claim 28, Gochman in view of Hoyt has taught a method as described in claim 27. Gochman has not explicitly taught that said branching to said first target address comprises selecting said first target address and providing said first target address as a fetch address to an instruction cache in the microprocessor. However, Official Notice is taken that instruction caches from which instruction bytes are fetched are well known and accepted in the art. Instructions are always fetched from some form of memory, whether it be an instruction cache, main memory, etc. However, an instruction cache is much faster than main memory, and therefore, to increase fetching speed, and ultimately execution speed, it would have been obvious to one of ordinary skill in the art at the time of the invention to have Gochman's instruction fetch unit (Fig.4, component 30) coupled to an instruction cache. Also, addresses are inherently placed on an address bus. Finally, it should be realized from column 6, lines 51-54, and column 4, lines 41-45, that the first address is applied to an instruction cache in order to begin fetching instructions from the predicted path.

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60. Referring to claim 29, Gochman in view of Hoyt has taught a method as described in claim 28. Gochman has further taught that said generating said first target address comprises said first call/return stack generating said first target address in response to a previous fetch address that was provided to said instruction cache. From the basic description given in column 4, lines 4-56, a fetch address is applied to the branch target address cache. This fetch address also corresponds to a particular instruction which may or may not be a branch (call, return, etc.). If a hit occurs in the cache, then the instruction is a branch, and based on another field in the cache, if that branch is a return instruction, then the selected return address will be the one popped from the top of the first stack.

61. Referring to claim 30, Gochman in view of Hoyt has taught a method as described in claim 29. Gochman has further taught that said generating said first target address is performed whether or not a return instruction is present in an instruction cache line selected by said fetch address. See Fig. 4 and note that a return address (from stacks 51) is sent to a single multiplexer within branch prediction circuit 40. Therefore, the address is provided regardless of whether or not a return instruction exists. However, the multiplexer will not select the return address prediction if a return instruction does not exist within the cache; that is, it is made available, but it is not necessarily utilized. For instance, if the cache line includes an ordinary branch instruction (call), but not a return, then the multiplexer will select the address supplied by cache 41 as opposed to the address supplied by stack 51.

62. Referring to claim 31, Gochman in view of Hoyt has taught a method as described in claim 29. Gochman has further taught decoding a return instruction present in a line of instruction bytes selected from said instruction cache by said fetch address, wherein said

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decoding said return instruction present in said line of instruction bytes is performed subsequent to said branching to said first target address. Note from Fig.2 and column 4, lines 35-45, that the first address is obtained in the PF pipeline stage. By doing this, fetching instructions is continued so no stalling. The return instruction itself won't be fully decoded until three cycles later in the D2 stage.

63. Referring to claim 32, Gochman in view of Hoyt has taught a method as described in claim 31. Gochman has further taught that said generating said second target address comprises said second call/return stack generating said second target address in response to said decoding said return instruction present in said line of instruction bytes. See Fig.2 and note that the second (actual) return address is popped off of second (actual) stack during the E (execute) stage. However, it is inherent that execution occurs in response to decoding because a system cannot execute an instruction without knowing the type of instruction. Therefore, since execution occurs in response to decoding, and the popping occurs during execution, then the popping occurs in response to the decoding.

64. Referring to claim 39, Gochman has taught a microprocessor for predicting return instruction target addresses.

a) Gochman has not explicitly taught an instruction cache, for providing a line of instructions in response to a fetch address received on an address bus. However, Official Notice is taken that instruction caches from which instruction bytes are fetched are well known and accepted in the art. Instructions are always fetched from some form of memory, whether it be an instruction cache, main memory, etc. However, an instruction cache is much faster than main memory, and therefore, to increase fetching speed, and ultimately execution speed, it would have been obvious

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to one of ordinary skill in the art at the time of the invention to have Gochman's instruction fetch unit (Fig.4, component 30) coupled to an instruction cache. Also, addresses are inherently placed on an address bus.

b) a multiplexer, having a plurality of inputs, configured to select one of said plurality of inputs for provision on said address bus as said fetch address to said instruction cache. See Fig.4, and note the multiplexer which receives input from the branch target buffer cache, one of the two stacks, and the write-results stage of the pipeline. This multiplexer will select one of multiple addresses that will be sent on the address bus to the instruction cache.

c) a speculative branch target address cache (BTAC), coupled to said address bus, for indicating a speculative presence of a return instruction in said line of instructions. See Fig.4, component 41, and column 4, lines 16-25.

d) a speculative call/return stack, coupled to said speculative BTAC, for providing a speculative return address to a first of said plurality of multiplexer inputs in response to said speculative BTAC indicating said speculative presence of said return instruction. See Fig.1 and Fig.4, component 51, and column 6, lines 4-25, and lines 48-56.

e) decode logic, configured to receive and decode said line of instructions. See Fig.4, component 60.

f) a non-speculative call/return stack, coupled to said decode logic, for providing a non-speculative return address to a second of said plurality of multiplexer inputs in response to said decode logic indicating that said return instruction is actually present in said line of instructions. See Fig.1 and Fig.4, component 55. Note that this stack provides an actual (non-speculative) address, via popping, during the E (execute) stage (Fig.2). It is inherent that execution occurs in

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response to decoding because a system cannot execute an instruction without knowing the type of instruction. Therefore, since execution occurs in response to decoding, and the popping occurs during execution, then the popping occurs in response to the decoding.

g) a comparator, coupled to said speculative and non-speculative call/return stacks, for comparing said speculative and non-speculative return addresses. See column 7, lines 20-25, and Fig.3, and note that a determination is made (via comparison) as to whether a branch has been mispredicted or not.

h) wherein said multiplexer selects said speculative return address in a first instance, and selects said non-speculative return address in a second instance subsequent to said first instance if said comparator indicates that said speculative and non-speculative return addresses do not match.

As the Fig.3 shows, if a misprediction did not occur (the speculative return address was correct, i.e., it matches the actual return address), then the process is done and execution continues.

However, if a misprediction did occur (the speculative return address was incorrect, i.e., it does not match the actual address), then the instruction fetch must be restarted at the actual return address. Also, see column 7, lines 20-32, and Fig.2 for further details.

i) Gochman has not taught that comparing an address from a non-speculative stack with a first address occurs prior to the return instruction reaching an execution stage of a pipeline of the processor, wherein said execution stage is configured to finally resolve the return instruction. However, Hoyt has taught such a concept. See Fig.2, steps 1, 2, and 3. Both Gochman and Hoyt teach predicting a return address as early as possible and verifying a prediction after executing the return instruction. Hoyt teaches the concept which Gochman lacks, and that is verifying the prediction before the execution stage. See Fig.2, step 2, and column 13, lines 49-63. The idea

behind Hoyt is to speculatively predict returns as soon as possible (Fig.2, step 1), even as the existence of the return is unknown. Then before, the instruction is executed, it is decoded, verified by the decoding process to be a return instruction, and if so, makes sure the prediction is proper (Fig.2, step 2, and column 13, lines 7-10). When comparing Gochman and Hoyt, one of ordinary skill in the art would've realized that in Gochman, a prediction is made early and the verification happens during execution, which means a misprediction is detected further from the initial prediction. With Hoyt, verification happens before execution and therefore, a misprediction is noticed sooner, thereby allowing Hoyt to correct the problem in less time. As a result, in order to verify predictions sooner in Gochman, which would allow for earlier correction of mispredictions, it would have been obvious to one of ordinary skill in the art at the time of the invention to modify Gochman to include the comparing prior to execution feature set forth in Hoyt.

65. Claims 9-10 and 36 are rejected under 35 U.S.C. 103(a) as being unpatentable over Gochman in view of Hoyt, as applied above, in view of Hilgendorf et al., U.S. Patent No. 5,974,543 (as applied in the previous Office Action and herein referred to as Hilgendorf).

66. Referring to claim 9, Gochman in view of Hoyt has taught an apparatus as described in claim 6. Gochman in view of Hoyt has not taught that said BTAC is further configured to cache a plurality of lengths of a corresponding plurality of call instructions previously executed by the processor. However, Hilgendorf has taught such a concept. See column 8, line 60, to column 9, line 16, and note that the BHT (branch history table / BTAC), provides the length of the call instruction so that it can be added to the fetch address (i.e., the address of the call instruction) to

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realize the return address. A person of ordinary skill in the art would have recognized that such a system gives the user increased flexibility in that return addresses can be calculated in variable instruction length systems, where instruction length is not always constant. Consequently, in order to achieve this flexibility, it would have been obvious to one of ordinary skill in the art at the time of the invention to modify the BTAC of Gochman to include the length of the branch instruction.

67. Referring to claim 10, Gochman in view of Hoyt in view of Hilgendorf has taught an apparatus as described in claim 9. Hilgendorf has further taught that said first return address comprises a sum of an instruction cache fetch address and one of said plurality of lengths provided by said BTAC. Again, see column 8, line 64, to column 9, line 5.

68. Referring to claim 36, Gochman in view of Hoyt has taught a method as described in claim 35. Gochman has not taught that said calculating said first target address comprises adding a cached length of a previously cached call instruction and a fetch address selecting an instruction cache line potentially including said previously executed call instruction. However, Hilgendorf has taught such a concept. See column 8, line 60, to column 9, line 16, and note that the BHT (branch history table / BTAC), provides the length of the call instruction so that it can be added to the fetch address (i.e., the address of the call instruction) to realize the return address. A person of ordinary skill in the art would have recognized that such a system gives the user increased flexibility in that return addresses can be calculated in variable instruction length systems, where instruction length is not always constant. Consequently, in order to achieve this flexibility, it would have been obvious to one of ordinary skill in the art at the time of the invention to modify the BTAC of Gochman to include the length of the branch instruction.

69. Claims 11-12 are rejected under 35 U.S.C. 103(a) as being unpatentable over Gochman in view of Hoyt in view of Hilgendorf, as applied above, and further in view of Shiell et al., U.S. Patent No. 5,850,543 (herein referred to as Shiell).

70. Referring to claim 11, Gochman in view of Hoyt in view of Hilgendorf has taught an apparatus as described in claim 10. Gochman in view of Hoyt in view of Hilgendorf has not explicitly taught that said BTAC is further configured to cache a plurality of byte offsets within an instruction cache line of said corresponding plurality of call instructions, said byte offsets being within an instruction cache line selected by said fetch address. However, Shiell has taught such a concept. See Fig.3 (offset field), column 4, lines 31-33, and column 8, lines 34-43. Having such an offset allows the system to track the location of a branch instruction within an instruction line. Consequently, it would have been obvious to one of ordinary skill in the art at the time of the invention to modify Gochman's BTB to include a byte offset.

71. Referring to claim 12, Gochman in view of Hoyt in view of Hilgendorf has taught an apparatus as described in claim 11. Furthermore, it is inherent that said instruction cache line is selected by said fetch address. When you fetch a line from cache, you want to fetch the line corresponding to the fetch address.

72. Claims 13 and 37 are rejected under 35 U.S.C. 103(a) as being unpatentable over Gochman in view of Hoyt in view of Hilgendorf in view of Shiell, as applied above, and further in view of Col et al., U.S. Patent No. 6,108,773 (herein referred to as Col).

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73. Referring to claim 13, Gochman in view of Hoyt in view of Hilgendorf in view of Shiell has taught an apparatus as described in claim 10. They have not taught that said first return address comprises a sum of said instruction cache fetch address and said one of said plurality of lengths and one of said plurality of byte offsets. However, Col has taught such a concept. See column 10, lines 42-58. Note the return target (sequential address to the branch) is the fetch address (segment base) + offset (instruction pointer) + length of the instruction. A person of ordinary skill in the art would have recognized that the target may be calculated in many different ways and it is dependent on the type of system. Consequently, it would have been obvious to one of ordinary skill in the art at the time of the invention to modify Gochman in view of Hilgendorf and further in view of Shiell to add the aforementioned components together to achieve the target address.

74. Referring to claim 37, Gochman in view of Hoyt in view of Hilgendorf and further in view of Shiell has taught a method as described in claim 36. They have not taught that said generating said first target address comprises adding said fetch address, said cached length, and a cached offset of said call instruction within said instruction cache line. However, Col has taught such a concept. See column 10, lines 42-58. Note the return target (sequential address to the branch) is the fetch address (segment base) + offset (instruction pointer) + length of the instruction. A person of ordinary skill in the art would have recognized that the target may be calculated in many different ways and it is dependent on the type of system. Consequently, it would have been obvious to one of ordinary skill in the art at the time of the invention to modify Gochman in view of Hilgendorf and further in view of Shiell to add the aforementioned components together to achieve the target address.

***Conclusion***

75. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. Applicant is reminded that in amending in response to a rejection of claims, the patentable novelty must be clearly shown in view of the state of the art disclosed by the references cited and the objections made. Applicant must also show how the amendments avoid such references and objections. See 37 CFR § 1.111(c).

Patel et al., U.S. Patent No. 6,134,654, has taught a bi-level branch target prediction scheme with fetch address prediction. Looking at the abstract, two predicted addresses are generated and compared and if the first equals the second, the first is used; otherwise the second is used.

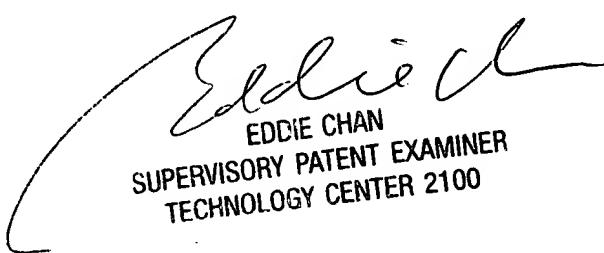
Any inquiry concerning this communication or earlier communications from the examiner should be directed to David J. Huisman whose telephone number is (571) 272-4168. The examiner can normally be reached on Monday-Friday (8:00-4:30).

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Eddie Chan can be reached on (571) 272-4162. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

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Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

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March 25, 2005

  
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